III. REMARKS

The present invention is a method of growing semiconductor epitaxial layers on a substrate in which the supersaturation of the growth solution and the composition the layers is controlled by varying the pressure of a non-growth source constituent gas rather than the temperature. As the control of pressure is a developed technique, and the pressure can be changed rapidly and accurately, this means that supersaturation can be controlled more easily. Furthermore, the phase diagram of the solid layer ingredients as a function of pressure is monotonous and quasi-linear, which as a function of temperature it is complicated and non-monotonous. This means that it is easier to control the solid layer ingredients when using the method of the invention. The method also allows graded layers to be grown, and makes iterative growth processes easier, resulting better quality epitaxial layers and great flexibility in the growth process.

Bauser discloses a method utilizing centrifugal force from rotation of growth chamber, not just to transport liquid solution to growth wafer, but also to "control local supersaturation of solution at growth surface". The centrifugal force is the primary activator, and leads to a concentration increase in the immediate vicinity of growth solution directly above the substrate. It is this concentration increase that results in supersaturation of solution at the locality of the interface of growth wafer. Pressure, being force per unit area, is just the accompanying parameter, and it depends on the surface area of the substrate.

The present invention varies the supersaturation of the growth solution directly via the pressure of the gas ambient

inside the growth chamber. Note that the pressure is exerted uniformly and evenly in the growth solution, and not as in Bauser's case being localized just at the growth solution-substrate interface. Ambient pressure is the primary independent activator of supersaturation in the present invention.

Bauser's centrifugal force, and hence the accompanying pressure, depends on the mass of the atoms in the growth solution. This means that the method is only limited to the growth on a single element material onto the substrate. It will be very difficult to grow a compound semiconductor material with 2 or more elements (such as InP), since only the atoms of the heaviest element will be concentrating at the growth interface to affect the local supersaturation there.

In the present invention, the masses of the various elements required to realize the material composition for a particular epitaxial layer are first determined and then all the sources are loaded into the growth crucible and chamber for baking and homogenization. Subsequently, the ambient pressure acts upon this entire prepared growth solution, enabling the growth of a layer of compound semiconductor with doping, if desired, which is not possible with Bauser's method. Of course, growth of a single elements material is easily realizable in our invention.

Consequently, the various features pointed out above and in our earlier submission go beyond that of the limitations of Bauser's method (which is physically true). Basically, Bauser's centrifugal force based local supersaturation variation is conceptually diff rent from our ambient pressure varied supersaturation in the whole growth solution.

Claim 1 now recites "...uniformly varying the pressure of a non-growth source constituent gas..." This is totally missing from Bauser, and thus the rejection of claim 1 and 9 under 35 USC 102 of this reference should be withdrawn.

Dugger makes a passing comment in the Background Section that the "degree of supersaturation can be changed by other means, such as evaporation of the solvent, or by changes in the pressure of the solution. The conventional way of influencing supersaturation in solution growth is by change of the solution temperature." (Col. 3, lines 16-21). Besides this statement, there is no further elaboration or teaching of the method and its physical effects. In fact, in his invention, Dugger further goes on to utilize the temperature variation effect for the aluminum nitride crystal growth. It is submitted that this merely passing comment is an insufficient disclosure as compared with applicants multipage disclosure of how to use pressure changes to change growth. Transclean Corp. v. Bridgewood Services, Inc., 62 USPQ 2d 1865 and for a case specifically dealing with epitaxial growth see Rockwell International Corp. v. United States, 47 USPQ 2d 1027, 1031.

It should be noted that there is no further prior art or publication on pressure-controlled supersaturation in liquid phase epitaxy growth. Hence, it is respectfully submitted that it is incorrect to conclude that such a cursory comment without any further elaboration/teaching disclosed and point towards the concept described in our invention.

More importantly, the method disclosed by Dugger is for the three-dimensional growth of bulk single crystals, and this is not the presently claimed "epitaxial", which is the growth of a thin film such that the atomic arrangement matches that on

surface of the substrate. In contrast, the present method teaches the growth of a two-dimensional thin film grown epitaxially on top of a substrate. For such thin film epitaxial growth, lattice-matching to the substrate is very important to obtain good quality films, implying that good material composition control of film is a pre-requisite.

Bernardi discloses a method to overcome the problem of mercury evaporation during the epitaxial growth of HgCdTe compound. Here, a mercury vapor ambient for the growth solution is generated so that proper composition control is possible with the mercury vapor over-pressure.

It is not obvious that combining Bernardi's method of epitaxial growth of HgCdTe with Dugger's single-sentence reference on supersaturation control in bulk aluminum nitride crystal growth results in the present invention. The material systems for both cases and type of growth (epitaxial film versus bulk crystal) are different and incompatible. Thus combining these references is impossible. Even if they are somehow combined, the result is not the present invention since the claim epitaxial feature would be missing. Therefore the rejection of claims 1-2, 5 and 7 under 35 USC 103 on these references should be withdrawn.

Cook discloses a method of utilizing a gas bubble to separate two growth solutions, and moving this bubble to transport a desired growth solution to a growth substrate.

Here, the gas pressure is utilized to transport the desired growth solution onto the growth substrate.

It is incorrect to claim that combining the bubble transport mode of Cook and Dugger's single-sentence reference on supersaturation control in bulk aluminum nitride crystal growth teaches the present invention. The pressure in Cook's method is applied only during movement of the bubble and is not implemented during actual growth where the growth solution is in direct contact with the substrate. Hence, it is not possible for the pressure in Cook's method to control the supersaturation of the growth solution.

Thus the rejection of claims 3-4 and 6-7 under 35 USC 103 over Bernardi in view of Dugger and Cook should be withdrawn.

Hsieh discloses a method of supercooling to grow thin epitaxial layers by temperature variation (lowering) and control. Again, it is two far-fetched to claim that Dugger's single-sentence mention on pressure-based supersaturation control in bulk crystal growth, together with the temperature induced supercooling effect for epitaxial growth of Hsieh, disclose the teaching of our invention.

Thus, the rejection of claims 10 and 11 under 35 USC 103 on Bernardi in view of Dugger and Hsieh should be withdrawn.

For similar reasons the rejection of claims 1 and 8-11 under 35 USC 103 over Hsieh in view of Dugger should be withdrawn.

For reasons given above, the rejection of claims 2 and 5 under 35 USC 103 over Hsieh, Dugger, and Bernardi should be withdrawn.

Also the rejection of claims 3-11 under 35 USC 103 on Hsieh, Dugger, Bernardi, and Cook should be withdrawn.

Also the rejection of claims 3-11 under 35 USC 103 on Hsieh, Dugger, Bernardi and Cook should be withdrawn for similar reasons.

Concerning Porowski:

1) It discloses a method to grow nitride-based layers (GaN, AlN or InN) in a high pressure chamber with group III metal and nitrogen gas as the growth sources.

2) Essentially, this is homoepitaxy (meaning growth of one type of material, which is determined by the group III metal source) in two steps:

3) The first step is to use high pressured nitrogen to grow the required nitride layer, followed by growth conditions of a lower temperature and pressure to grow the same nitride layer,

4) The second layer is grown at a lower rate (col 3, lines 22-24), resulting in one with better crystal quality and surface flatness (col 3, lines 29-30).

5) After growth of the first type of material in a two-layer process, the other layers are then grown by other methods such as molecular beam epitaxy or chemical vapor deposition (col 3, lines 62-65).

Although the pressure during growth is varied, it should be noted that nitrogen gas used forms part of the growth source besides the group III metal, and there is no discussion on supersaturation control. Other high-pressured gases, such as hydrogen, will not result in the required nitride growth. In addition, this is homoepitaxy, and there is no teaching of multilayer growth of layers of different material composition within the high pressure growth chamber. In fact, in one of embodiments (Claim 10 part d), the second layer is grown with the vapor of group III metal and nitrogen gas, and this method cannot be still classified as liquid phase epitaxy.

In the present invention, varying the pressure inside the growth chamber directly affects the degree of supersaturation so that epigrowth occurs on the growth substrate. The gas used does not act as one of the growth source, but is used to prevent oxide formation. In addition, multilayer of different material

composition and doping can be easily realized with the graphite boat pull mechanism.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

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